Reconstruction of sedimentary basin properties using Bayesian fusion: theoretical framework and applications

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Defining a “complete, multi-physics model” of a sedimentary basin, i.e. its structure and its physical properties, is fundamental for the exploration of its geo-resources. Single models of complementary physical properties (e.g. elasticity and resistivity) have often been integrated to obtain a multi-physics model of basins. However, integrating single models that (a) exploit observables displaying different depth- resolutions, (b) are based on data recorded during different surveys, i.e. observables collected with different field geometry, and (c) are obtained using different geophysical tools, i.e. different methodologies for solving different geophysical inverse problems, is not a trivial problem. One of the key-issues that needs to be faced is the correct estimation of the uncertainties on the final “complete model” parameters, which requires the coherent “weighting” of the different single models with the final solution.

We present a new “Bayesian fusion” algorithm, where results obtained during previous investigations of a rock volume are re-appraised within the same volume. The new technique exploits previous information on each physical property in form of known Posterior Probability Distribution (PPD) of the parameter over the study volume. Such PPDs are integrated in a single 3D structure (i.e. all the physical parameters display the same geometrical distribution within the volume), where value of the physical properties are fully consistent with the assumed PPDs. The theoretical framework of the new algorithm is presented in details, for simple (e.g. integration of single 1D models in a 2D profile or 3D model) and complex cases (e.g. integration of models derived from both “derivative” and “integral” observables). Both synthetic and field measurements are used to illustrate the potential of the new algorithm.